Fish waste management by conversion into heterotrophic bacteria biomass

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Wageningen IMARES is een samenwerkingsverband tussen Wageningen UR en TNO

Wageningen IMARES

- Institute for Marine Resources and Ecosystem Studies
- strategic & applied marine ecological research
- Merger of Dutch Institute for Fisheries Research (RIVO), Alterra Texel and TNO (Den Helder)
- Ecology, Environment, Fisheries, Aquaculture (150 FTE)
- 3 Locations (North, Middle, South of NL)
- Aquaculture Department: 15 FTE (2007)

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Structure

- RAS Waste – A problem and its solution?
- Integration of heterotrophic bacteria conversion
  - System
  - Factors
  - Results
- Conclusions

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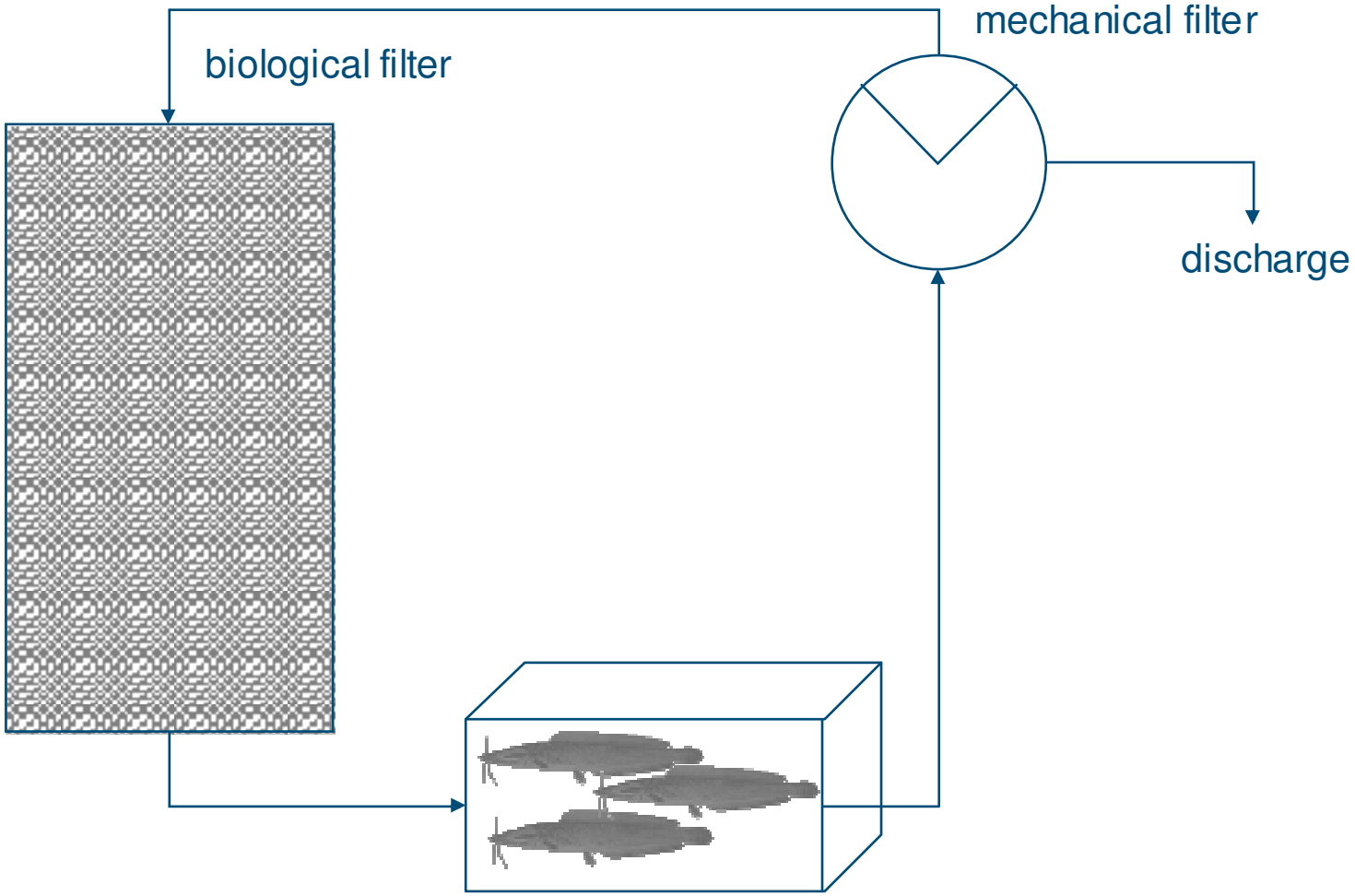
RAS Waste….



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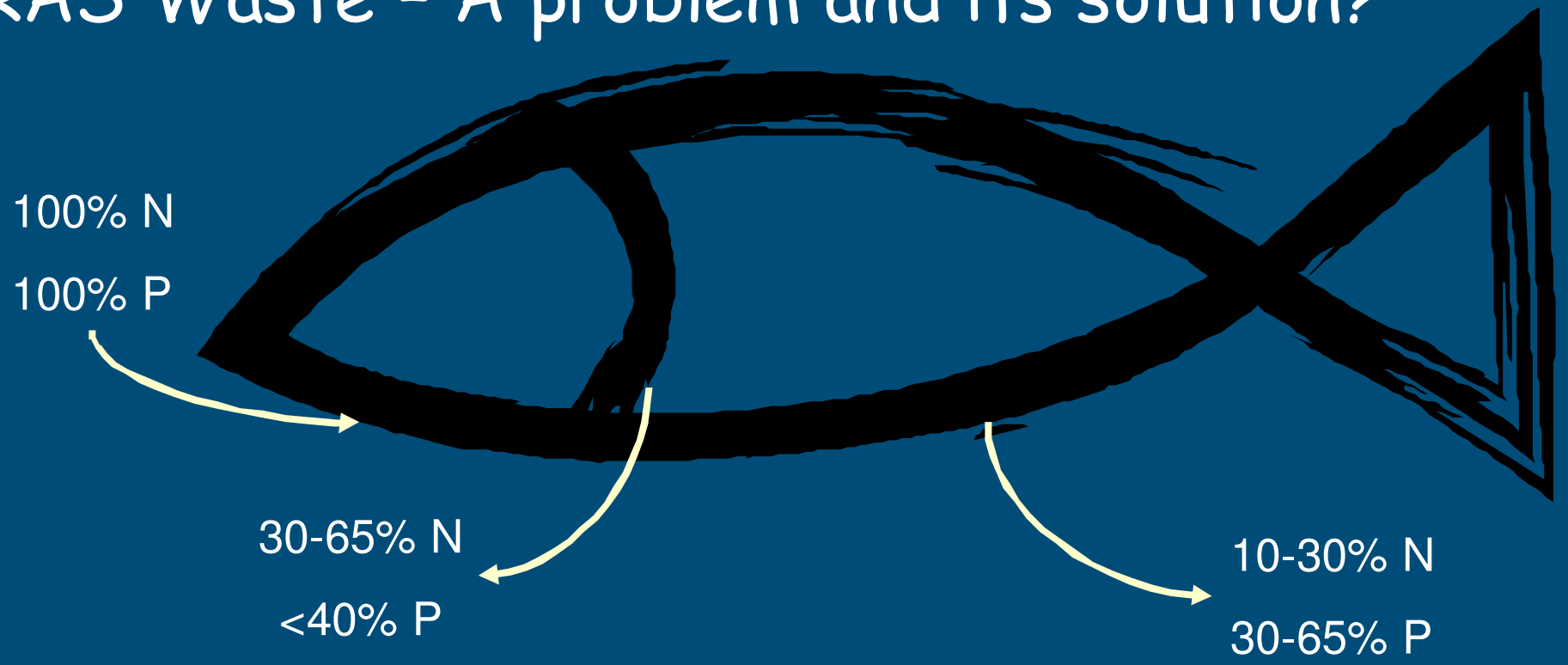
RAS Waste - A problem and its solution?



- SOLUTION
  - Waste treatment inside the systems
    - Solid removal, nitrification, denitrification, dephosphatation etc
  - Waste management outside the system

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Schneider, O, Sereti, V, Eding, EH & Verreth, JAJ (2004) Analysis of nutrient flows in integrated intensive aquaculture systems. *Aquacultural Engineering* **32**: 379-401.

Waste Characteristics

	Concentration	Load (g-kg feed)
TAN	1.3 (0.3–4.8) mg/l	-*
NO_2-N	3.3 (0.7–12.4) mg/l	-*
NO_3-N	182 (76–419) mg/l	40.4*
Kjd-N	59 (13–260) mg/l	7.8
TOC	0.4 (0.1–0.9) g/l	73.1
Ortho-P	15.1 (6.2–40.1) mg/l	5.5
Ash	1.8 (0.9–5.0) g/l	157
TS	3.5 (1.9–7.3) g/l	227
TSS	1.5 (0.2–5.8) g/l	182
VSS	0.7 (0.04–2.23) g/l	146
Drum filter (60 µm)	130 l/kg feed	

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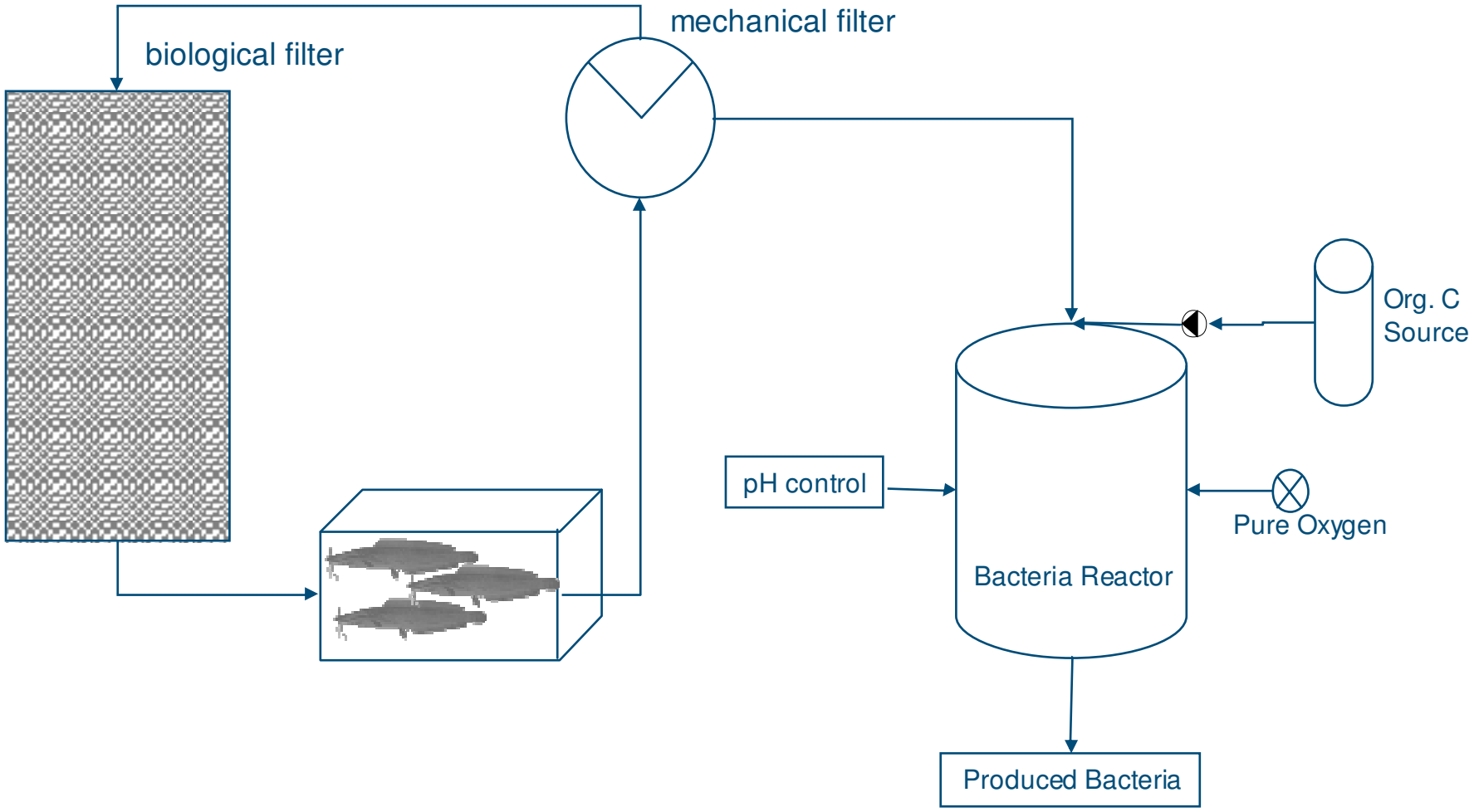
Schneider, O, Sereti, V, Eding, EH, Verreth, JAJ & Klapwijk, A (2007) Kinetics, design and biomass production of a bacteria reactor treating RAS effluent streams. *Aquacultural Engineering* **36**: 24-35.

Another Solution…



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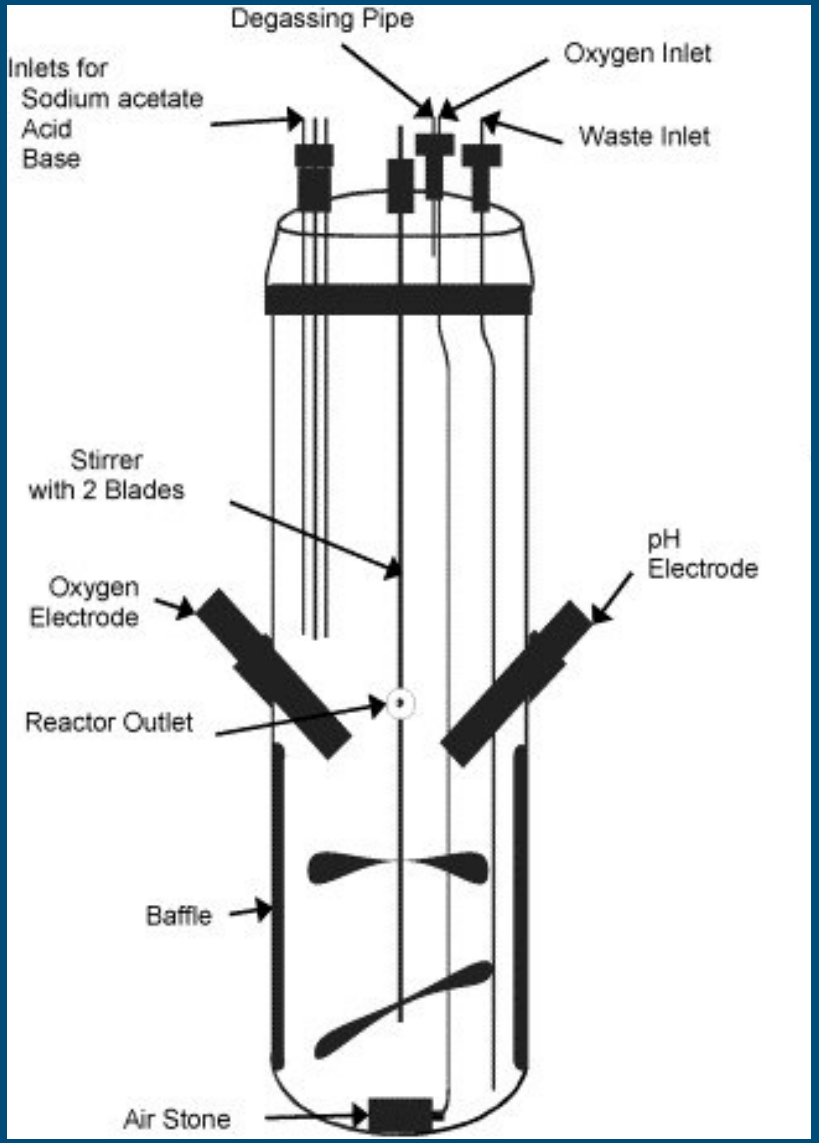
… - Bacteria Reactor



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Integration of heterotrophic bacteria conversion - Factors

Process

- Carbon supplementation level
- Carbon source
- Nitrogen source
- Production
- Kinetics

Product

- Bacteria community
- Re-use potential

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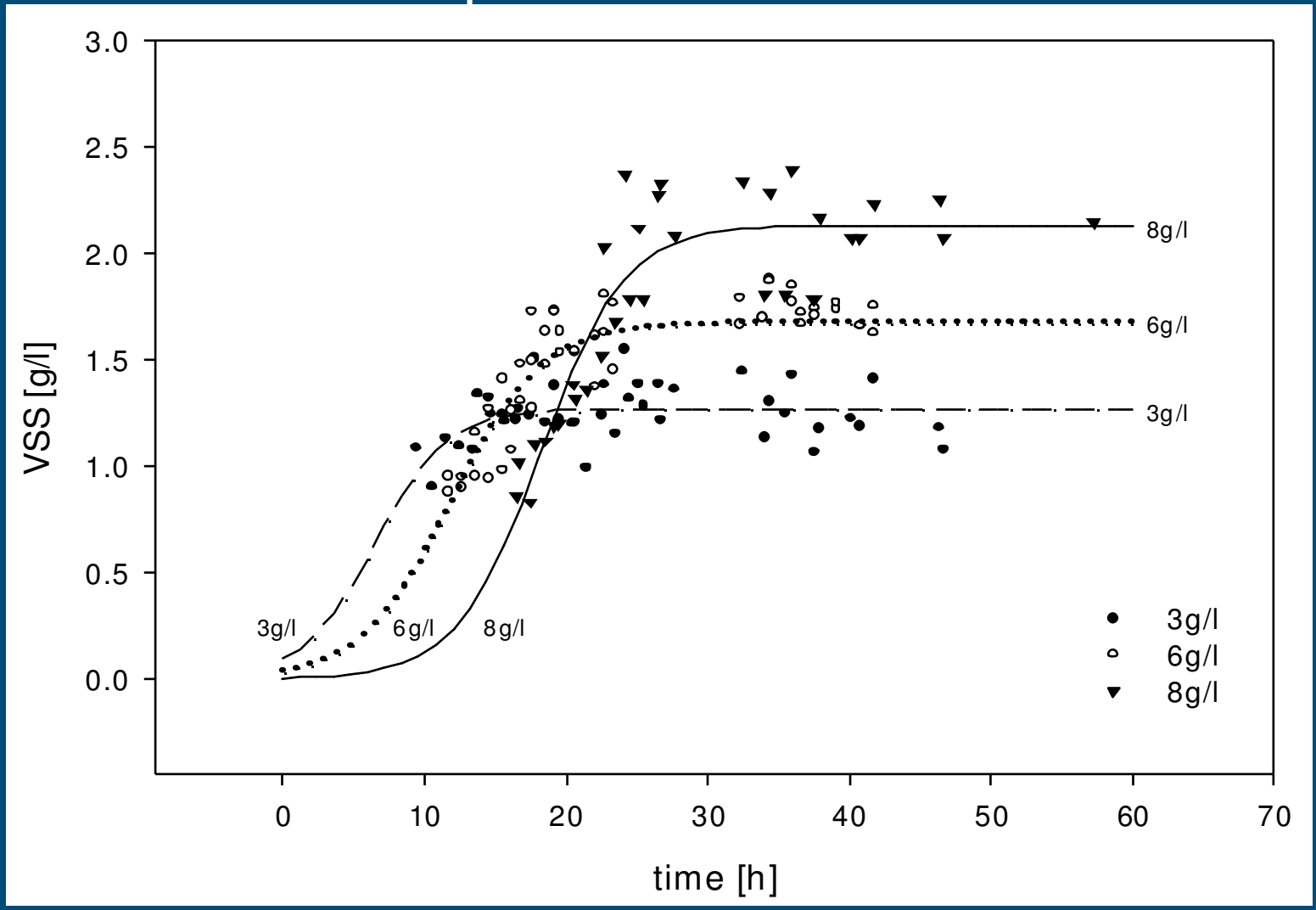
Integration of heterotrophic bacteria conversion – Results I



VSS = measure for bacteria

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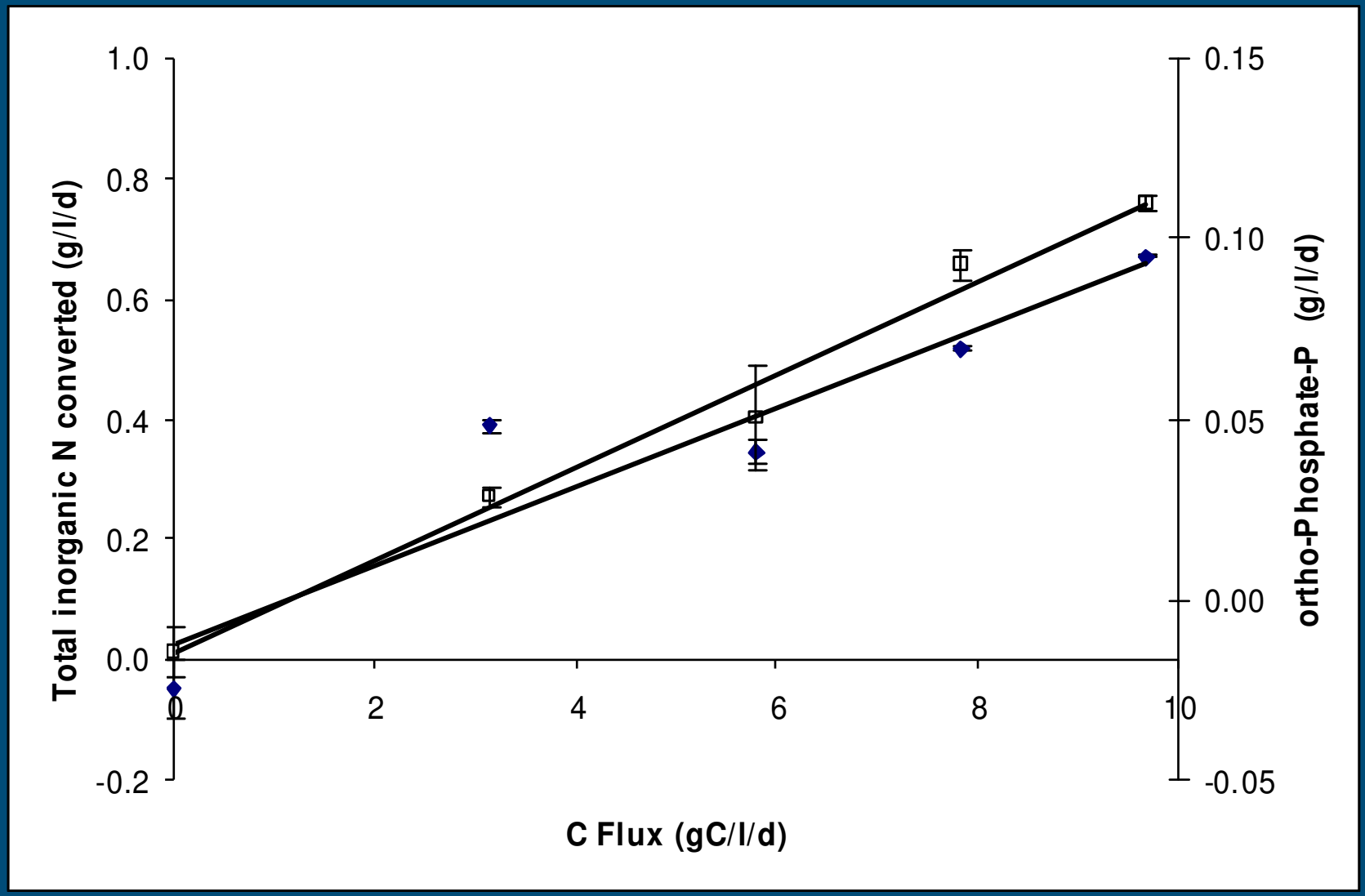
Schneider, O, Sereti, V, Machiels, MAM, Eding, EH & Verreth, JAJ (2006) The potential of producing heterotrophic bacteria biomass on aquaculture waste. *Water Research* **40**: 2684-2694.

Carbon Source (Molasses)



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Schneider, O, Sereti, V, Eding, EH & Verreth, JAJ (2006) Molasses as C source for heterotrophic bacteria production on solid fish waste. *Aquaculture* **261**: 1239-1248.

Nitrogen Source

Energy transfer efficiency 0.35; TAN yield 0.6gVSS/gC

$$0.125CH_3COO^- + 0.17O_2 + 0.016NH_4^+ \rightarrow 0.016C_5H_7O_2N + 0.059CO_2 + 0.109HCO_3^- + 0.109H_2O$$

$$0.125CH_3COO^- + 0.15O_2 + 0.014NO_3^- + 0.014H^+ \rightarrow 0.014C_5H_7O_2N + 0.057CO_2 + 0.125HCO_3^- + 0.084H_2O$$

→ 20% more yield for TAN

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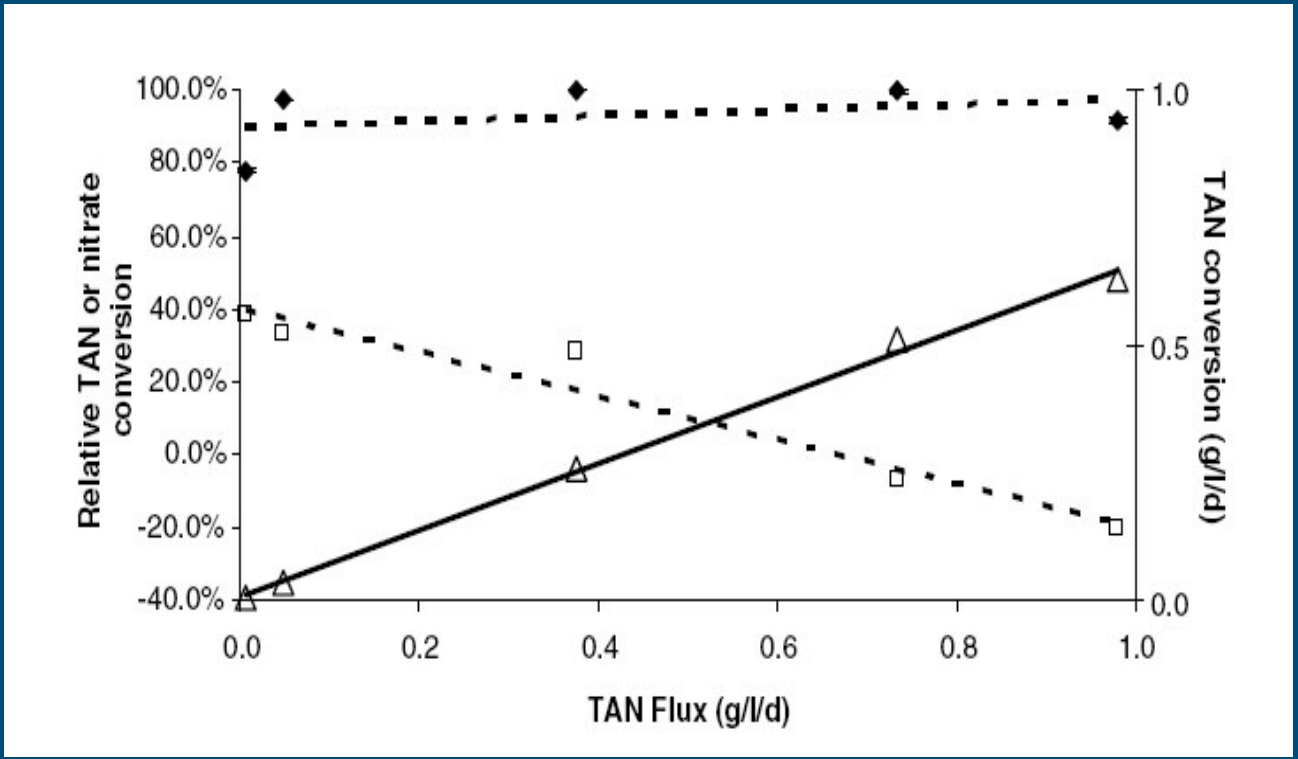
Schneider, O, Sereti, V, Eding, EH & Verreth, JAJ (2007) Heterotrophic bacterial production on solid fish waste: TAN and Nitrate as nitrogen source under practical RAS conditions. *Bioresour Technol* **98**: 1924-1930.

Nitrogen Source



♦ absolute TAN conversion

Δ relative TAN conversion

□ relative Nitrate-N conversion

No significant difference in yield!

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Production

- VSS 100-120gVSS/kg feed
- 90-95% dissolved N and P converted

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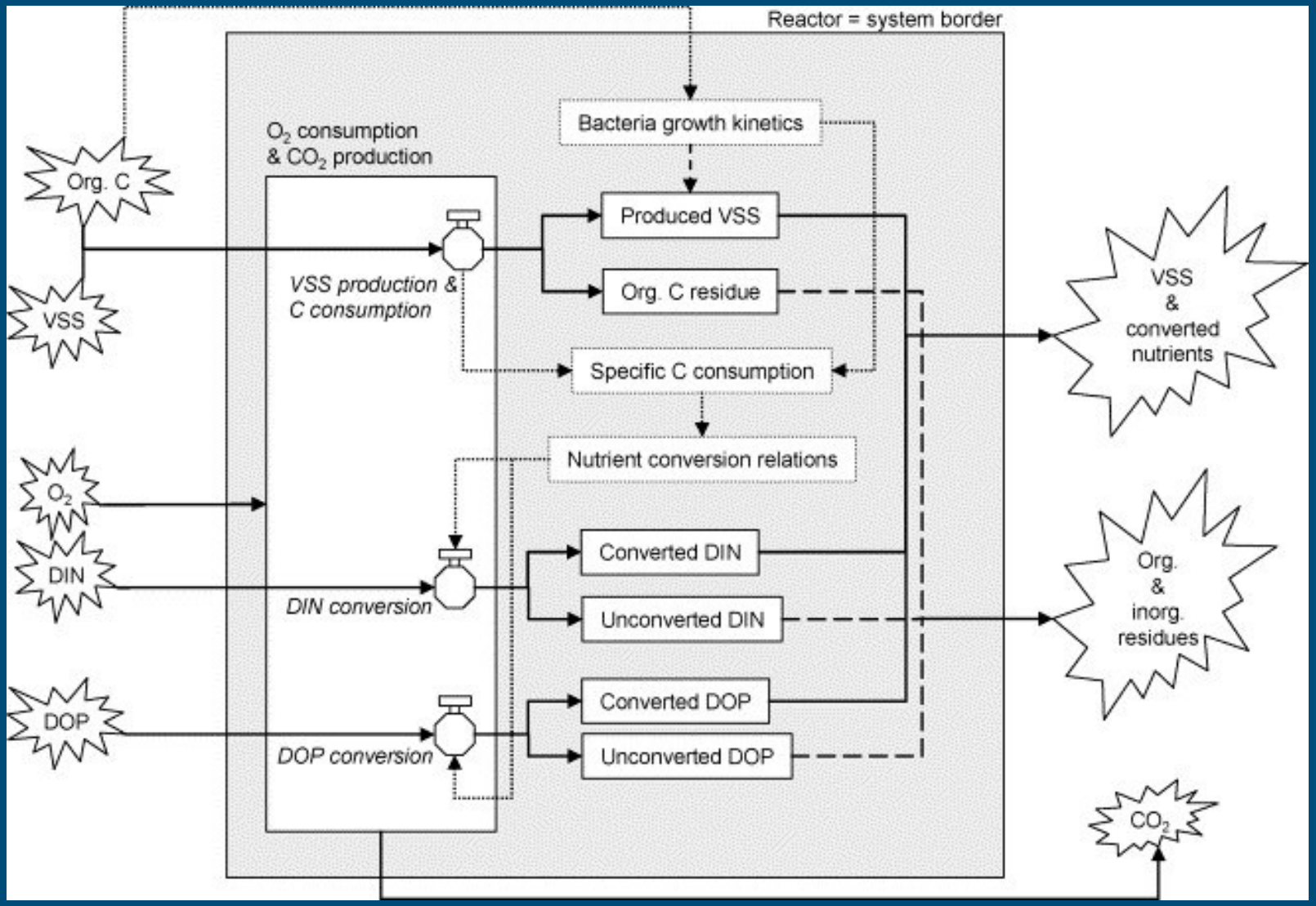
Modelling Bacteria Kinetics



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Model Parameters

Yield, Y	g VSS/g C	0.537
Endogenous decay coefficient, k_d	h^{-1}	0.033
Maximum specific growth rate, μ_{max}	h^{-1}	0.217
Half-velocity constant, K_s	g/l	0.025
Maximum rate of substrate utilization, k	g C/g VSS h	0.404

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Model Output

VSS production	g VSS/kg feed	187 ± 2
Dissolved inorganic nitrogen (reactor effluent)	mg N/l	47.4 ± 9.4
Dissolved inorganic nitrogen (conversion efficiency)	%	85 ± 3.0
Ortho-phosphate-phosphorus (reactor effluent)	mg P/l	1.4 ± 1.1
Ortho-phosphate-phosphorus (conversion efficiency)	%	95 ± 2.5
Organic carbon use	g C/kg feed	455
Carbon dioxide production	g CO_2/kg feed	1244 ± 31
Oxygen consumption	g O_2/kg feed	905 ± 23

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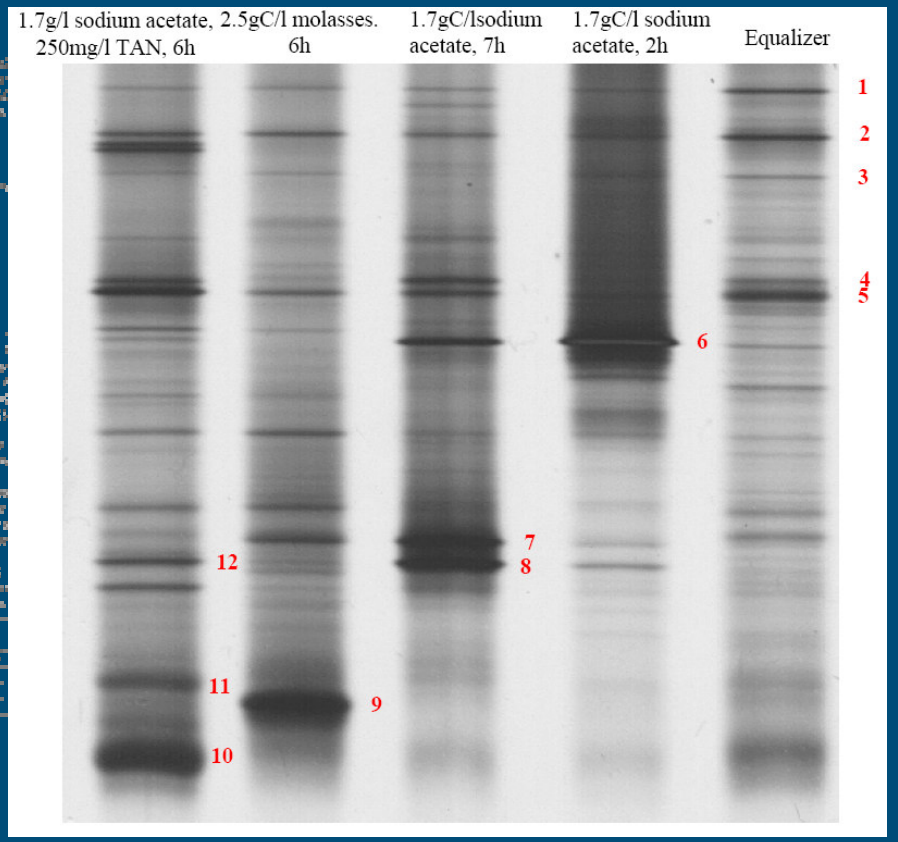
Bacteria

- Basically not pathogenic for recommended HRT
- Typical for aquatic environments/waste water



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Schneider, O, Chabrillon-Popelka, M, Smidt, H, Haenen, O, Sereti, V, Eding, EH & Verreth, JAJ (in press) HRT and nutrients affect bacterial communities grown on Recirculation Aquaculture System effluents. *FEMS Microbial Ecology*.

Products

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Schneider, O, Cong, TL, Sereti, V, Schrama, JW, Eding, EH & Verreth, JAJ (2006) Bacteria or commercial diet: The preferences of Litopenaeus vannamei. *Aquaculture Research* **37**: 204-207.

Conclusion

Integration of heterotrophic bacteria conversion to manage the waste effluent of a RAS together with a secondary crop is a prospective tool to increase RAS sustainability in the future…

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Ongoing Research @ IMARES

- Integration of Shrimps – Bacteria – Shellfish
- First results on shellfish = positive
- Sources: R&D, SME, Grants
- Contact: oliver.schneider@wur.nl

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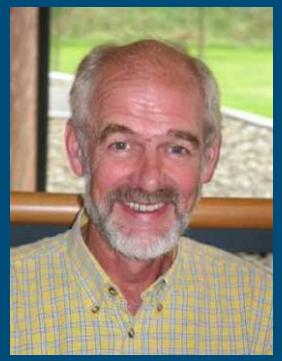
Acknowledgements















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10th International Conference on Shellfish Restoration (ICSR)
Vlissingen, The Netherlands, 12 - 16 November 2007

Theme: "Innovation in the exploitation and management of shellfish resources"

Topics:

- **recruitment** (e.g. spatfall dynamics and management)
- **ecosystem based management** (e.g. carrying capacity, integrated multitrophic aquaculture)
- **stakeholder involvement and management** (e.g. shellfish management and nature conservations, international legislation, education)
- **new technologies** (e.g. offshore shellfish culture, hatchery/nursery)

Information and registration
www.icsr2007.wur.nl
icsr-imares@wur.nl

INTERNATIONAL CONFERENCE ON SHELLFISH RESTORATION